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PHOMA BLIGHT: ITS HISTORY AND CONTROL AT THE HUMBOLDT NURSERY

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ABSTRACT

The history and biology of Phoma, as observed at the Humboldt Nursery, are described. Past control methods are summarized and methods of control including chlorothalonil, chlorothalonil and a sticker, mulching, applying lath, and inoculating with mycorrhizae are discussed. Increasing seedling size and precision sowing are suggested as considerations for reducing disease development.

INTRODUCTION

Phoma blight, caused by Phoma eupyrena, is the most damaging disease at the USDA Forest Service Humboldt Nursery located near Arcata, California. More than 10 million Douglas-fir, 1 million red fir and 670,000 white fir seedlings were lost due to Phoma from 1979-1983. Arcata's maritime climate, 60 inches average of annual rainfall, temperate winters and summertime coastal fog provide ideal conditions for fungal infection of 1-0 Douglas-fir, and 1-0 and 2-0 red and white fir.

The most effective control for Phoma blight has been chlorothalonil used in a preventive spray program. In 1981, chlorothalonil was detected by the North Coast Water Resources Board in a tributary of a creek that flows near the nursery. Drainage and runoff water from the nursery is concentrated into a sump which traps sediments and topsoil. During periods of heavy rainfall and peak water runoff, sump overflow is dissipated into an adjacent field which drains into this creek. Due to this contamination problem, the use of chlorothalonil was curtailed and extremely heavy losses were sustained at the nursery in 1981-1982. In Douglas-fir, an alternate method of control has not been developed for operational use in the nursery. In true fir, hydromulch is routinely applied, and has reduced damage.

The objectives of this paper are to describe the biology of the pest, to review and evaluate the control measures that have been used, and to discuss alternative, but untested, control measures that might provide adequate control of the fungus in an economically sound manner with minimum impact on human health and the environment.

PHOMA BIOLOGY

Phoma spp. are common soil fungi that are usually considered to be weak parasites. The fungus is present in the soil in the form of resistant mycelial structures called chlamydospores. Soil splash during winter and early spring causes a build up of soil around the stem and lower crown of small Douglas-fir and true fir seedlings. The fungus grows out of the soil cone and enters the seedling through the lower needles on Douglas-fir or lateral and terminal buds on true fir. In Douglas-fir, the fungus kills infected needles, but does not spread throughout the seedling. In beds of Douglas-fir, initial symptoms are usually needle chlorosis. Frequently the needles turn golden brown and drop. The disease causes a loss of the lower needles. Dieback or blight of terminals and lateral branches occurs in true fir. The dieback starts at or near the buds, progresses down the stem, and may result in seedling death. The fungus forms fruiting bodies (pycnidia) that appear as black raised spots on the dead needles and stems.

Phoma has been found damaging Douglas-fir and red and white fir at Humboldt Nursery. It has been found on Douglas-fir, true fir, Engelmann spruce, ponderosa pine, lodgepole pine, Jeffrey pine and sugar pine in the Pacific Northwest. The *Phoma* isolated from true fir, *Phoma eupyrena*, is morphologically identical to the *Phoma* associated with blight on Douglas-fir, but complete pathogenicity testing has not been done. A *Phoma* isolate from red fir was pathogenic to Douglas-fir when added to autoclaved soil.

In Oregon and Washington, *Phoma* is associated with three different types of disease: lower stem canker, upper stem canker and Phoma tip blight. In upper and lower stem canker, *Phoma*, in conjuction with *Fusarium* and other soil-borne fungi, causes a lesion along the seedling stem. This symptom has not been observed at the Humboldt nursery. The description of "Phoma tip blight" (see appendix) is similar to the syndrome found in Northern California on true fir. In the appendix of this report are literature reviews for upper stem canker, lower stem canker and Phoma tip blight. Upper and lower stem canker are included for comparative purposes and general background information.

CONTROL METHODS

Past trials

The following is a brief synopsis of the trials done to control Phoma blight at Humboldt Nursery.

Ten fungicides to control Phoma blight of red fir were evaluated at the Humboldt Nursery (Kliejunas, 1983). Fungicides were applied at approximately one month intervals from September 1982 to May of 1983. Efficacy was

determined by comparing the percentage of red fir killed in each treated plot with adjacent untreated plots. None of the fungicides tested effectively controlled Phoma blight of red fir. The following fungicides were tested : chlorothalonil (Bravo W-75), captafol (Difolatan 4F), tri-basic copper sulfate (Tri-basic), mancozeb (Dithane M-45), Benomyl (Benlate), Triforine (Triforine EC), triadimefon (Bayleton 50 WP), iprodione (Chipco 26019), vinclozolin (Ornalin 50 W), etaconazole (Vangard 10 W).

In 1984, Bravo W-75 and Bravo 500 were compared for their relative efficacy in controling Phoma blight on Douglas fir and red fir (Freeman, 1984). In Douglas-fir, the two formulations were equally effective in controlling Phoma blight. Neither formulation controlled Phoma blight of red fir.

The efficacy of chlorothalonil, mancozeb, and tri-basic copper sulfate were tested alone and in combination with a redwood mulch or shade cover (Freeman, 1984). When compared with no cover, the use of either a mulch or lath cover significantly reduced soil splash, subsequent soil cone formation and disease development when compared to bare ground. No significant diffences among fungicide treatments were found. When compared with no fungicide treatment, none of the three fungicides tested, in combination with either no cover or with a mulch or lath cover, significantly reduced the number of dead red fir seedlings.

In 1985, Soil Seal Concentrate, a latex acrylic copolymer, was applied to a bed of 1-0 Douglas-fir in an attempt to reduce or prevent soil cone formation (Freeman, 1985). There were no significant differences in degree of soil cone formation among the treated and untreated areas.

In 1986-1987 a trial was set up in red fir to evaluate the effectiveness of the following chemicals: cholorothalonil, diniconazole, penconazole, myclobutanil, prochloraz and iprodione. No disease developed in control or treated plots, and no comparisons could be made.

<u>Cultural methods</u>

The following cultural techniques have been used at Humboldt nursery for control of Phoma blight. Sowing of Douglas-fir seed in March rather than May has decreased damage. Early sowing results in greater seedling top growth during the first year. The foliage that is above soil cones formed over the winter seldom becomes infected. Redwood mulch has reduced soil cone formation and disease incidence in red fir beds.

<u>Chemical control</u>

The preventative spray recommendation, based on early trials by McCain and Smith (unpublished) uses chlorothalonil (Bravo 500) applied at 2 to 4 week intervals during the dormant season (October to April) at a rate of 2 lbs/100 gals water/acre. This regime has reduced Phoma blight on Douglas-fir and true fir. In heavy rainfall years the treatment is less effective.

MANAGEMENT ALTERNATIVES

The following alternatives should be considered in developing a control strategy for Phoma blight.

1. Chemical control. A review of past trials and experience indicates that under periods of high rainfall there is no adequate chemical control for *Phoma* in red fir. In Douglas-fir, chlorothalonil is the only chemical that reduces *Phoma* infection adequately. However, it does not provide complete control and is hazardous to human health and the environment if not used prudently.

Currently, only Douglas-fir seedlings under 4 to 6 inches tall at the end of the first growing season are sprayed. The total acreage sprayed each year is less than 5 acres.

The following alternatives could be pursued:

a. Rebuild sump and alter drainage pattern so residues do not leave nursery and use chlorothalanil. This would eliminate the problem of residues departing the nursery. It would not reduce potential hazard to employees handling seedlings. Several options for redesigning the sump are being evaluated. Building an additional sump is also a possibility. It is estimated that reconstruction would take several years and cost over $100,000. Another method being considered is installation of a filter system that would remove residues before they left the nursery. Estimated cost of a filter system is $200,000.

b. Use a sticker or other chemical additive with chlorothalanil to reduce residue in soil and water. SDS Biotech, manufacturer of Bravo, does not recommend use of any chemical additives with its product. The formulation has been tested and the manufacturer believes that effectiveness is greatest when applied alone (George Chisom, personal communication). Although effectiveness may be reduced, a test of efficacy with a sticker may be worthwhile. A potentially small reduction in performance might be tolerable if a decrease in runoff could be achieved.

c. Find a new fungicide that is effective in controlling the disease. A cursory review of chemical company new product lines did not turn up any new chemicals with potential for *Phoma* control. This search for experimental chemicals should be continued, but since the conifer nursery market is a minor use, no chemical specifically designed for control of this problem can be expected to be developed. A search should be focused on surveying chemicals for ornamental or agricultural crops. If a chemical looked promising, efficacy trials could be initiated to determine effectiveness at Humboldt nursery.

2. Cultural control. Early sowing, mulching, lath cover, and mycorrhizal inoculation have all been effective *Phoma* control measures at Humboldt nursery.

a. Maximize seedling size. Sow early, fertilize, and do every management technique possible to produce the largest seedling possible. This will cause the seedlings to be less susceptible to infection, because foliage is further away from soil splash. Nursery personnel estimate that if Douglas-fir seedlings are larger than 4 to 6 inches tall at the end of the first growing season, then they will not become infected with *Phoma*. Infection occurs in the

fall after the first growing season. After this time, production techniques could be switched to slow growth by undercutting and cutting back on fertilization, ensuring that the seedlings are not too large at lift. If seedlings can be sold as 1-0, the Phoma problem may be eliminated. Informing the users of the benefits of large seedlings in increased survival may be needed if these production changes are made.

b. Mulch. A number of materials could be applied to the soil surface to reduce soil splash and soil cone formation. Sawdust, bark chips, sand, and chemical soil seals have been successfully used in nurseries for erosion control. Toxicity to seedlings and abrasion to equipment is lowest for sawdust mulch. Of the various materials available, sawdust is usually relatively inexpensive if a local source can be found. Trials need to be done to determine what time of year is best for application. It would be easiest from a production standpoint to apply the mulch just after sowing. Trials at Humboldt have shown that mulch is effective in reducing soil splash in the fall. Soil Seal Concentrate, a chemical soil sealant, was not effective in reducing soil cone formation (Freeman, 1985). Other products are available (Geotech etc.), and further investigation into their usefulness is needed. The use of mulch with a sealant on top of it could be tested.

Mulching is expensive. There are 20 acres of Douglas-fir to be protected each year. At a cost of approximately $700 per acre, the cost to the nursery would be approximately $14,000.

c. Lath. This technique may be too expensive and cumbersome on an operational scale. It did, however, reduce disease development in a trial on red fir.

d. Mycorrhizae inoculation. The mycorrhizal status of seedlings at Humboldt is not known. An evaluation should be done to determine species present and percent infection. Srago inoculated Douglas-fir by chopping up root trimmings infected with mycorrhizae and applying them to fumigated soil. This seemed to increase overall seedling size and reduce disease development (Srago, personal communication). There are risks of pathogen introduction when root clippings are applied to soils, but this could be eliminated by growing fungal inoculum for application to beds. To keep costs down, inoculum could be produced at the nursery.

e. Precision sowing. Precision sowing to ensure uniform bed densities may be effective in reducing disease. Any technique that would reduce seedling clumpiness and provide a uniform canopy protecting the soil from direct rain penetration would reduce soil cone formation. Since soil cones are necessary for infection to occur, a uniform canopy should reduce infection levels.

3. Biological control. Little or no effort has gone into controlling Phoma (or other diseases) through biological agents. The development of a biological control would be a long term project and would require a large commitment of research money and manpower.

4. Grow red fir at Placerville Nursery. The climate at the Placerville nursery is drier and less conducive to disease development. The Placerville nursery is currently at capacity and, unless an exchange could be arranged, any addition of seedlings to Placerville would eliminate the production of something else.

Red fir can, however, be successfully grown at Placerville, although some seed sources may perform better at Humboldt. Due to the acreage needed to grow large numbers of Douglas-fir, this alternative is not feasible for Douglas-fir.

RESEARCH NEEDS

For control measures to be developed intelligently, the disease cycle must be throughly understood. At this time there are large gaps in our knowledge of Phoma's disease cycle. Research is needed to answer the following questions: Is fumigation effective in eradicating Phoma? If so, where does Phoma come from following fumigation? How does Phoma survive? What are inoculum levels in soil? What levels are needed to cause disease? What conditions are needed for successful infection?

Until these questions are answered, the nursery is left with a shot-gun approach to reducing disease losses from the pathogen.

LITERATURE CITED

1. Freeman, Wilfred L., Jr. 1984. Bravo W-75 versus Bravo 500 for control of Phoma blight at Humboldt Nursery. USDA Forest Service, Pacific Southwest Region, Forest Pest Management Report No. 84-34. San Francisco. 2 p.

2. Freeman, Wilfred L., Jr. 1984. Results of 1983-1984 trials for control of Phoma blight of red fir at Humboldt Nursery. USDA Forest Service, Pacific Southwest Region, Forest Pest Management Report No. 84-39. San Francisco. 3 p.

3. Freeman, Wilfred L. Jr. 1985. Efficacy of Soil Seal Concentrate for reducing soil cone formation in nursery beds at Humboldt Nursery. USDA Forest Service, Pacific Southwest Region, Forest Pest Managment Report No. 85-32. San Francisco, 2 p.

4. Kliejunas, J., Allison, J. and McCain, A., 1983. Evaluation of fungicides for the control of Phoma blight of red fir and Sirococcus tip blight of Jeffrey pine at the Humboldt Nursery. USDA Forest Service, Pacific Southwest Region, Forest Pest Management Report No. 83-22. San Francicso. 8 p.

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31. Ziller, W.G. and R.S. Hunt. 1972. *Lophodermium pinastri* needle cast of pines in nurseries and plantations. Forest Insect and Disease Survey, Canada, Pest Leaflet No. 52.

Briefly reviews the hosts, distribution and life history of this fungus, which causes serious defoliation on *Pinus sylvestris* Christmas trees in the lower Fraser Valley, British Columbia, and elsewhere, and discusses control measures.

Lower Stem Canker

(*Fusarium roseum, Phoma eupyrena*)

We found eight references on lower stem canker. All work on this disease to date has been done in the Pacific Northwest, primarily on Douglas-fir. Since this is a recently recognized disease, there are no reports earlier than 1984. Five articles cover the biology of the complex of organisms which cause the disease (1, 4, 5, 6, 7); one paper deals with impact and detection (2); one deals with chemical control (3); and one is a general paper on management techniques (8).

1. Anonymous. 1985. Nursery pathology research project. Oregon State University Forest Research Laboratory Nursery Technology Cooperative, Annual Report 1984-85, p.11-12.

After two years of detailed disease monitoring, some aspects of the top blight disease complex of Douglas-fir have been clarified. Pathogens involved include *Fusarium oxysporum* on hypocotyls, *Phoma eupyrena*, and *Fusarium roseum* on the upper stem, and *P. eupyrena*, *F. roseum*, and *Phoma pomorum* on the lower stem during the first year, and *Phomopsis* near the base of new growth in the second year. All fungi involved are soil inhabitants, spread by rain and soil movement; therefore soil management will be the key part of any successful control.

2. Bega, R.V. 1984. Factors contributing to a severe root-aerial disease complex at a large conifer nursery. IN: Western International Forest Disease Work Conference, Proceedings 32:67-68.

The Forest Service Humboldt Nursery is suffering large losses of *Pseudotsuga menziesii*, *Abies magnifica*, *A. concolor*, and *P.*

ponderosa seedlings. Isolation of organisms was attempted from diseased seedlings which were stunted, somewhat chlorotic, with a severely restricted root systems, numerous rootlet lesions and some stem and needle lesions. The most consistently isolated organisms were *Fusarium oxysporum*, *Pythium*, and *Phoma*.

3. Cooley, S.J. and A. Kanaskie. 1986. Evaluation of seven fungicides to control canker diseases of bare-root Douglas-fir in Pacific Northwest nurseries. USDA Forest Service, Pacific Northwest Region, Report R6-86-14.

The fungicides Benlate®, Captan®, Chipco 26019®, Daconil 2787®, Difolatan®, Mertect®, and Zyban® were applied periodically at five nurseries in Oregon and Washington for control of Douglas-fir canker diseases. Hypocotyl rot, resulting from ground-line infections by *Fusarium oxysporum*, was reduced by Benlate® at two nurseries; the other fungicides were less effective. Upper stem infections resulting in top mortality were caused primarily by *Phoma* spp. and *Fusarium* spp. and occurred in October and early November. In two nurseries that experience relatively high levels of upper stem canker, all fungicides significantly reduced cankering. Lower stem cankers, seen in spring and summer of the second year, were not controlled by fungicides if cankers were at groundline; good control was achieved with Daconil® and Difolatan® when cankers were higher on the stem and not covered with a soil collar. Cankers caused by *Botrytis* were prevalent in the summer and fall of the second year at one nursery; all fungicides gave effective control, although Daconil® and Difolatan® were superior.

4. Hamm, P.B. and E.M. Hansen. 1987. Stem canker disease of Douglas-fir in nurseries. IN: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, General Technical Report RM-137, p.106-108. Western Forest Nursery Council and Intermountain Nursery Association Meeting, Proceedings, edited by T.D. Landis. Held August 12-15, 1986, Tumwater, Washington.

Diseases that kill above-ground portions of Douglas-fir formerly called "top blight" are listed. Disease recognition, time of infection, infection site, and causal agents are described.

5. Hamm, P.B., E.M. Hansen, and A.M. Kanaskie. 1985. Symptomology of the "top blight" diseases of Douglas-fir bare-root seedlings in nurseries in the Pacific Northwest. Phytopathology 75(11):1367.

Top blight, an ill-defined syndrome, describes at least three distinct periods of mortality. In mid-summer, when seedlings are 3 months old, a hypocotyl rot occurs at or just above the soil line. Seedling tops quickly turn brown while roots are not discolored. *Fusarium oxysporum* is isolated. From September through November, cankers, centered on bark fissures, lateral or terminal shoots, or needle scars, appear between the midstem and seedling apex. *F. roseum* and *Phoma eupyrena* are recovered. A third type of symptom, December through May, is associated with soil collars built up by irrigation and splashing rain. Seedlings are girdled at or above the cotyledon scar, with top symptoms sometimes not evident until new growth suddenly wilts during the spring. *F. roseum* and *P. eupyrena* are most frequently isolated from diseased seedlings.

6. Hansen, E.M. and P.B. Hamm. 1988. Canker diseases of Douglas-fir fir seedlings in Oregon and Washington bareroot nurseries. Canadian Journal of Forestry Research (In Press).

Canker diseases in northwestern forest nurseries have been referred to collectively as "top blight." To distinguish among the various symptoms and their associated fungi, systematic observations of and isolations from *Pseudotsuga menziesii* seedlings through two crop cycles in four northwestern nurseries were made, and suspect fungi were subjected to pathogenicity testing. Five diseases were distinguished. Hypocotyl rot, caused by *Fusarium oxysporum*, kills seedlings during their first growing season. Upper stem canker, caused by *Phoma eupyrena* and *Fusarium roseum*, girdles seedlings in mid-stem in the fall of their first year. Lower stem canker, also caused by *P. eupyrena* and *F. roseum*, kills seedlings in the winter or early spring of their second year and is associated with soil collars built up by splashing water. *Botrytis* and *Phomopsis* cankers occasionally kill new shoots during the second year. Not all diseases are damaging every year or in every nursery.

7. James, R.L. and P.B. Hamm. 1985. Chlamydospore-producing species of *Phoma* from conifer seedlings in Pacific Northwest forest tree nurseries. Montana Academy of Science, Proceedings 45:26-36.

Three species of *Phoma* that produce chlamydospores in culture are frequently isolated from diseased conifer seedlings from several Pacific Northwest nurseries. These include *P. eupyrena*, *P. glomerata*, and *P. pomorum*. Major differentiating characteristics of these species include abundance and morphology of chlamydospores, growth habit in culture, conidial exudate color and conidial pigmentation, shape, septation, and size. Cultural characteristics of these three *Phoma* species and a brief description of their habit in nature are discussed.

8. Kanaskie, A. 1987. Management of the top blight disease complex. IN: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, General Technical Report RM-137, p.115-121. Western Forest Nursery Council and Intermountain Nursery Association Meeting, Proceedings, edited by T.D. Landis. Held August 12-15, 1986, Tumwater, Washington.

The "top blight disease complex" refers to five separate but related diseases affecting above-ground portions of bareroot Douglas-fir seedlings. Disease losses can be reduced by altering cultural practices or applying fungicides. The following paper provides practical approaches and techniques for reducing losses from top blight.

Phoma Tip Blight

(*Phoma* spp.)

We found 11 references on Phoma tip blight. All work on this disease has been done in the west including Oregon, northern California, Idaho, and Montana. A variety of tree species are hosts to *Phoma*, including Douglas-fir, red fir, Englemann spruce, ponderosa, lodgepole, Jeffrey and Scotch pines. The majority of references are detection or impact reports (2, 3, 4, 5, 6, 7, 11). The remainder deal with the biology of the organism (8, 10) or some aspect of disease management (1, 9).

1. Freeman, W.L., Jr. 1984. Results of 1983-1984 trials for control of Phoma blight of red fir at the Humboldt Nursery. USDA Forest Service, Pacific Southwest Region, Report 84-39.

Previous tests of fungicides for the control of Phoma blight had been ineffective, but observations indicated that prevention of soil cone formation would lessen the impact of the disease. This trial, using three fungicides in combination with a redwood mulch or shade frames to decrease rain splash, was conducted in 1983-84. Results showed that both the mulch and the lath cover significantly reduced the incidence of Phoma blight, but none of the fungicide treatments significantly reduced the number of seedlings killed, either with or without the mulch or cover.

2. James, R.L. 1980. Engelmann spruce needle and twig blight at the Coeur d'Alene Nursery, Idaho. USDA Forest Service, Northern Region, Forest Insect and Disease Management, Report 80-21.

Needle and twig blight of *Picea engelmannii* was investigated to determine probable causes and formulate recommendations for reducing future losses. The two major fungal genera consistently isolated from symptomatic seedlings were *Phoma* and *Botrytis*. Diseases caused by *Phoma* and *Botrytis* can usually be effectively controlled with fungicides. Chlorothalonil is registered for *Phoma* and is most effective when applied at 2-week intervals during cool, wet weather. Fungicide application has traditionally been used to control Botrytis blight; however, development of tolerance to certain chemicals by various strains of the fungus have been reported. No fungicides are currently registered for *Botrytis* at the Coeur d'Alene Nursery.

3. James, R.L. 1983. Fungi associated with tip dieback of ponderosa pine seedlings at the Clifty View Nursery, Bonners Ferry, Idaho. USDA Forest Service, Northern Region.

1-0 ponderosa pine seedlings were examined to determine possible causes of tip dieback and necrosis. *Sirococcus strobilinus* was isolated from 10 percent of the seedlings received. *Phoma eupyrena* and *P. herbarum* were commonly found sporulating on and were isolated from necrotic tissues both at the

tips and at the base of affected seedlings. *Diplodia pinea* was infrequently isolated from tip blighted seedlings. *Epicoccum nigrum* was commonly isolated from necrotic stem and needle tissues. In addition, four isolates of *Sirococcus strobilinus* were screened for possible tolerance to chlorothalonil. The isolates examined were not very tolerant; however, sustained heavy doses of the fungicide may select for more tolerant strains of the fungus.

4. James, R.L. 1984. Tip blight of ponderosa pine seedlings at the Fantasy Farms Nursery, Peck, Idaho. USDA Forest Service, Northern Region, Cooperative Forestry and Pest Management, Report 84-3.

An evaluation was conducted to identify fungi associated with tip blight and dieback of ponderosa pine seedlings. The disease was most prevalent in 1-0 pine seedbeds, where affected seedlings were scattered throughout beds rather than being concentrated in groups or restricted to certain areas. *Diplodia pinea* was identified as the major source of sporulation on necrotic tissues; *Phoma eupyrena* was also isolated.

5. James, R.L. 1987. Phoma tip blight of bareroot lodgepole pine seedlings, Champion Timberlands Nursery, Plains, Montana. USDA Forest Service, Northern Region.

Tip blight was located on several *Pinus contorta* seedlings in the spring of their second growing season. Microscopic examination revealed that they were from the genus *Phoma*. *Phoma* are common soil inhabitants and are usually controlled by fumigation of nursery soil prior to sowing. Disease incidence is usually not severe enough in Rocky Mountain nurseries to warrant specific control measures.

6. James, R.L. 1987. Tip blight of Scots pine seedlings - Montana State Nursery, Missoula. USDA Forest Service, Northern Region.

Tip blight of *Pinus sylvestris* was recently discovered in 2-0 seedbeds at the Montana State Nursery. Two species of *Fusarium* (*F. oxysporum* and *F. acuminatum*) and *Phoma pomorum* were

commonly found. Recent changes at the nursery have stressed soil treatment with fumigants, which should reduce future losses from tip blight, as well as damping-off and root diseases.

7. James, R.L. and S.J. Cooley. 1987. Tip blight of bareroot ponderosa and lodgepole pine seedlings - USDA Forest Service Nursery, Bend, Oregon. USDA Forest Service, Northern Region.

Diseased seedlings were collected during the summer of 1987 for analysis of fungi associated with tip dieback symptoms. Five genera of fungi were consistently found sporulating on necrotic stem tissues. These included *Phoma, Fuarium, Alternaria, Botrytis*, and *Epicoccum*. It was felt that *Phoma* and *Fusarium* were most likely responsible for tip blight symptoms, so the isolates were further identified to species. Two species of *Phoma, P. eupyrena* and *P. pomorum*, and two species of *Fusarium, F. oxysporum* and *F. acuminatum*, were isolated. *Phoma* and *Fusarium* spp. were likely soil inhabitants which were present in sufficient numbers to cause disease when environmental conditions were conducive to infection.

8. James, R.L. and P.B. Hamm. 1985. Chlamydospore-producing species of *Phoma* from conifer seedlings in Pacific Northwest forest tree nurseries. Montana Academy of Science, Proceedings, 45:26-36.

Three species of *Phoma* that produce chlamydospores in culture are frequently isolated from diseased conifer seedlings from several Pacific Northwest nurseries. These include *P. eupyrena, P. glomerata*, and *P. pomorum*. Major differentiating characteristics of these species include abundance and morphology of chlamydospores, growth habit in culture, conidial exudate color and conidial pigmentation, shape, septation, and size. Cultural characteristics of these three *Phoma* species and a brief description of their habit in nature are discussed.

9. Kliejunas, J. 1983. Fungicide trials for control of *Phoma* and *Sirococcus* at the Humboldt Nursery. IN: Western International Forest Disease Work Conference, 31:50-53.

Ten fungicides to control Phoma blight of red fir and five fungicides to control Sirococcus tip blight of Jeffrey pine were evaluated at the Humboldt Nursery. Fungicides were applied at approximately one month intervals from September 1982 to May or June 1983. Efficacy was determined by comparing the percentage of red fir killed or Jeffrey pine cankered in each treated plot with adjacent untreated plots. None of the fungicides tested effectively controlled Phoma blight of red fir. Three fungicide — chlorothalonil, ectaconazole, and triadimefon — were efficacious in controlling Sirococcus tip blight of Jeffrey pine; vinclozolin and iprodione were not.

10. Kliejunas, J.T., J.R. Allison, A.H. McCain, and R.S. Smith, Jr. 1985. Phoma blight of fir and Douglas-fir seedlings in a California nursery. Plant Disease 69(9):773-775.

Phoma eupyrena was consistently associated with needle cast and blight of red fir and Douglas-fir seedlings at a nursery near the coast of northern California. Symptoms typically developed during the dormant period between the first and second growing season. Heavy rains and soil splash resulted in the buildup of soil cones around the stem and lower crown, followed by infection of lower needles or buds by the soilborne fungus. Inoculations of greenhouse-grown seedlings with *Phoma eupyrena* in soil resulted in symptoms identical to those observed in the field. Protective fungicides tested on red fir gave little or no control. The addition of a redwood mulch and the use of a shade cover reduced soil splash, soil cone formation and disease incidence.

11. Srago, M. 1978. Nursery disease problems - Phoma blight. IN: Western Forest Nursery Council and Intermountain Nurseryman's Association, Conference and Workshop Proceedings, 1978, p.B138, edited by R.W. Gustafson. Held October 1978, Eureka, California.

In 1979 and 1975 there were major losses of 1-0 Douglas-fir at the Humboldt Nursery in McKinleyville, California. The

fungus most commonly isolated from the needles and stems of these declining trees has been a *Phoma* species. Although pathogenicity tests have not been conducted at this time, evidence suggests that *Phoma* spp. is the probably cause of the disease.

Phomopsis Canker

(*Phomopsis* spp.)

We have listed 15 references on Phomopsis canker. It occurs primarily on Douglas-fir in both the nursery and on young trees in the field (3, 5, 6, 9). Twelve of the 15 references are from the Pacific Northwest. Six references deal with the biology of *Phomopsis* (1, 5, 7, 8, 9, 14) and two are detection and impact reports (2, 3). There are three reports of chemical trials (4, 11, 12), one article discussing management via cultural means (15), and one which discusses use of both chemical and cultural methods (10). Two papers cover the biology and management of the disease in a general fashion (6, 13).

1. Anonymous. 1985. Nursery pathology research project. Oregon State University Forest Research Laboratory, Nursery Technology Cooperative, Annual Report 1984-85, p.11-12.

After two years of detailed disease monitoring, some aspects of the top blight disease complex of Douglas-fir have been clarified. Pathogens involved include *Fusarium oxysporum* on hypocotyls, *Phoma eupyrena* and *Fusarium roseum* on the upper stem and *P. eupyrena*, *F. roseum*, and *Phoma pomorum* on the lower stem during the first year, and *Phomopsis* near the base of new growth in the second year. All fungi involved are soil inhabitants, spread by rain and soil movement; therefore, soil management will be a key part of any successful control.

2. Bega, R.V. 1978. *Phomopsis lokoyae* outbreak in a California forest nursery. Plant Disease Reporter 62(7):567-569.

The fungus caused a major epidemic in Douglas-fir in the Forest Service Humboldt Nursery in McKinleyville, California, the first report of such an outbreak in a California nursery. The damage caused a drastic reduction in inventory and shipping estimates for the 1976 planting season.

16

7. Williams, R.E. 1972. Fungi associated with blister rust cankers on western white pine. Dissertation Abstracts 33B(6):2434.

Forty non-uredinaceous species of fungi were isolated from blister rust (*Cronartium ribicola*) cankers on *Pinus monticola*. Two fungi, *Cladosporium cladosporioides* and *Tuberculina maxima*, directly affect rust sporulation and spore dispersal, and occurred with relatively high frequency. They are not considered of value in controlling blister rust except for indirect effects on canker inactivation. Thirteen fungus species caused or were associated with canker necrosis, of which five may be suitable as biological control agents of blister rust.

Upper Stem Canker
(*Fusarium roseum, Phoma eupyrena*)

Only eight papers exist on upper stem canker because it is a disease of recent discovery. All of the papers describe this problem in Pacific Northwest nurseries. The hosts include Douglas-fir, some true firs, and ponderosa pine. Six of the papers deal with detection and biology (1, 2, 4, 5, 6, 7), one with chemical control (3), and one with management strategies (8).

1. Anonymous. 1985. Nursery pathology research project. Oregon State University Forest Research Laboratory, Nursery Technology Cooperative, Annual Report 1984-85, p.11-12.

After 2 years of detailed disease monitoring, some aspects of the top blight disease complex of Douglas-fir have been clarified. Pathogens involved include *Fusarium oxysporum* on hypocotyls, *Phoma eupyrena* and *Fusarium roseum* on the upper stem, and *P. eupyrena*, *F. roseum* and *Phoma pomorum* on the lower stem during the first year, and *Phomopsis* near the base of new growth in the second year. All fungi involved are soil inhabitants, spread by rain and soil movement; therefore soil management will be a key part of any successful control.

2. Bega, R.V. 1984. Factors contributing to a severe root-aerial disease complex at a large conifer nursery. IN: Western International Forest Disease Work Conference, Proceedings, 32:67-68.

The Forest Service Humboldt Nursery is suffering large losses of *Pseudotsuga menziesii, Abies magnifica, A. concolor* and *P. ponderosa* seedlings. Isolation of organisms was attempted from diseased seedlings which were stunted, somewhat chlorotic, with a severely restricted root system, numerous rootlet lesions and some stem and needle lesions. The most consistently isolated organisms were *Fusarium oxysporum, Pythium,* and *Phoma.*

3. Cooley, S.J. and A. Kanaskie. 1986. Evaluation of seven fungicides to control canker diseases of bare-root Douglas-fir in Pacific Northwest nursery. USDA Forest Service, Pacific Northwest Region, Report R6-86-14.

The fungicides Benlate®, Captan®, Chipco 26019®, Daconil 2787®, Difolatan®, Mertect®, and Zyban® were applied periodically at five nurseries in Oregon and Washington for control of Douglas-fir canker diseases. Hypocotyl rot, resulting from ground-line infections by *Fusarium oxysporum,* was reduced by Benlate® at two nurseries; the other fungicides were less effective. Upper stem infections resulting in top mortality were caused primarily by *Phoma* spp. and *Fusarium* spp. and occurred in October and early November. In two nurseries which experience relatively high levels of upper stem canker, all fungicides significantly reduced cankering. Lower stem cankers, seen in spring and summer of the second year, were not controlled by fungicides if cankers were at groundline; good control was achieved with Daconil® and Difolatan® when cankers were higher on the stem and not covered with a soil collar. Cankers caused by *Botrytis* were prevalent in the summer and fall of the second year at one nursery; all fungicides gave effective control, although Daconil® and Difolatan® were superior.

4. Hamm, P.B. and E.M. Hansen. 1987. Stem canker disease of Douglas-fir in nurseries. IN: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, General Technical Report RM-137, p.106-108. Western Forest Nursery Council and Intermountain Nursery Association Meeting, Proceedings, edited by T.D. Landis. Held August 12-15, 1986, Tumwater, Washington.

Diseases that kill above-ground portions of Douglas-fir, formerly called "top blight", are listed. Disease recognition, time of infection, infection site, and causal agents are described.

5. Hamm, P.B., E.M. Hansen, and A.M. Kanaskie. 1985. Symptomology of the "top blight", diseases of Douglas-fir bare-root seedlings in nurseries in the Pacific Northwest. Phytopathology 75(11):1367.

Top blight, an ill-defined syndrome, describes at least three distinct periods of mortality. In mid-summer, when seedlings are 3 months old, a hypocotyl rot occurs at or just above the soil line. Seedling tops quickly turn brown while roots are not discolored. *Fusarium oxysporum* is isolated. From September through November, cankers, centered on bark fissures, lateral or terminal shoots, or needle scars, appear between the midstem and seedling apex. *F. roseum* and *Phoma eupyrena* are recovered. A third type of symptom, December through May, is associated with soil collars built up by irrigation and splashing rain. Seedlings are girdled at or above the cotyledon scar, with top symptoms sometimes not evident until new growth suddenly wilts during the spring. *F. roseum* and *P. eupyrena* are most frequently isolated from diseased seedlings.

6. Hansen, E.M. and P.B. Hamm. 1988. Canker diseases of Douglas-fir seedlings in Oregon and Washington bareroot nurseries. Canadian Journal of Forestry Research (In Press).

Canker disease in northwestern forest nurseries have been referred to collectively as "top blight." To distinguish among the various symptoms and their associated fungi, we made systematic observations of and isolations from *Pseudotsuga menziesii* seedlings through two crop cycles in four northwest-

ern nurseries, and suspect fungi were subjected to pathogenicity testing. Five diseases were distinguished. Hypocotyl rot, caused by *Fusarium oxysporum*, kills seedlings during their first growing season. Upper stem canker, caused by *Phoma eupyrena* and *Fusarium roseum*, girdles seedlings in mid-stem in the fall of their first year. Lower stem canker, also caused by *P. eupyrena* and *F. roseum*, kills seedlings in the winter or early spring of their second year and is associated with soil collars built up by splashing water. *Botrytis* and *Phomopsis* cankers occasionally kill new shoots during the second year. Not all diseases are damaging every year or in every nursery.

7. James, R.L. and P.B. Hamm. 1985. Chlamydospore-producing species of *Phoma* from conifer seedlings in Pacific Northwest forest tree nurseries. Montana Academy of Science, Proceedings, 45:26-36.

Three species of *Phoma* that produce chlamydospores in culture are frequently isolated from diseased conifer seedlings from several Pacific Northwest nurseries. These include *P. eupyrena, P. glomerata*, and *P. pomorum*. Major differentiating characteristics of these species include abundance and morphology of chlamydospores, growth habit in culture, conidial exudate color and conidial pigmentation, shape, septation, and size. Cultural characteristics of these three *Phoma* species and a brief description of their habit in nature are discussed.

8. Kanaskie, A. 1987. Management of the top blight disease complex. IN: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, General Technical Report RM-137, p.115-121. Western Forest Nursery Council and Intermountain Nursery Association Meeting, Proceedings, edited by T.D. Landis. Held August 12-15, 1986, Tumwater, Washington.

The "top blight disease complex" refers to five separate but related diseases affecting above-ground portions of bareroot Douglas-fir seedlings. Disease losses can be reduced by altering cultural practices or applying fungicides. This paper provides practical approaches and techniques for reducing losses from top blight.

Brian Sutton, The Coelomycetes 1980 CMI

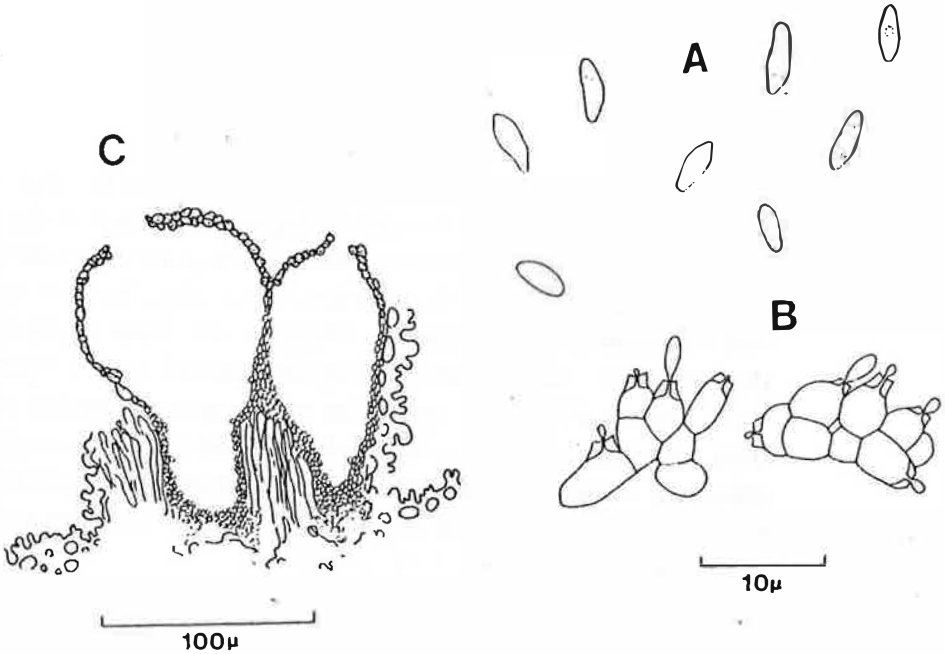

Fig. 225. *Metazythia caespitosa*, A, conidia; B, conidiophores with developing conidia; C, vertical section of conidiomata.

The genus is monotypic.

M. CAESPITOSA Petrak, *ibid.*: 373 (1950). (Fig. 225)

Conidiomata up to 100 µ diam. Conidiogenous cells 3-5 × 3-6.5 µ. Conidia 4-6 × 1.5-2 µ.

Hyperparasitic on indet. fungal stroma on *Chusquea serrulata*, Ecuador (IMI 201886, isotype ex ZT).

14. PHOMA Sacc., nom. cons., *Michelia* **2**: 4 (1880).
Phoma Fr. ex Fr., *Syst. Myc.* **1**: LII (1821); **2**: 546 (1823), nom. rej.
Plenodomus Preuss, *Linnaea* **24**: 145 (1851).
Leptophoma Höhn., *Sber. Akad. Wiss. Wien* **124**: 73 (1915).
Sclerophomella Höhn., *Hedwigia* **59**: 237 (1917).
Polyopeus Horne, *J. Bot. Lond.* **58**: 239 (1920).
Deuterophoma Petri, *Boll. R. Staz. Pat. Veg. Roma*, n.s. 9, **4**: 396 (1929).
? *Vialina* Curzi, *Boll. R. Staz. Pat. Veg. Roma*, n.s., **15**: 252 (1935).
Peyronellaea Goid. ex Goid. apud Togliani, *Ann. Sper. agr.*, N.S., **6**: 92 (1952).
Peyronellaea Goid., *R.C. Accad. Lincei*, ser. 8, **1**: 451 (1946).
Ascochyta Lib. sect. *Phyllostictoides* Zherbele, *Trudy vses. Inst. Zashch. Rast.* **29**: 20 (1971).
Sp. typ.: *P. herbarum* Westd.

Mycelium immersed, branched, septate, hyaline or pale brown. *Conidiomata* pycnidial, immersed, or semi-immersed, sometimes becoming erumpent, unilocular, brown, globose, separate or aggregated, occasionally confluent, thin-walled (in *P. lingam* becoming thick-walled and pseudosclerenchymatous); walls of thin-walled, pale to medium brown textura angularis. *Ostioles* single or several to each pycnidium, central, not papillate. *Conidiophores* only present in *P. cava* and *P. tracheiphila* and then either filiform, septate, and branched, or short, irregularly branched, and ramified respectively. *Conidiogenous cells* enteroblastic, phialidic, integrated or discrete, ampulliform to doliiform, hyaline, smooth, collarette and aperture minute, periclinal wall markedly thickened. *Conidia* hyaline, aseptate or occasionally 1 septate, thin-walled, often guttulate, ellipsoid, cylindrical, fusiform, pyriform or globose.

The generic synonymy for *Phoma* has been discussed by Sutton (1977a).

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Boerema (1974)
P. macdonaldii
Sedum.

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4. Chlam
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4. Chlam
5. Conidia 3
5. Colonies
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6. Pycn
6. Pycn

P. DESTRUCTIVA Plowr., *Gard. Chron.* 16: 621 (1881). (Fig. 226G)
Diplodina destructiva (Plowr.) Petrak, *Annls mycol.* 10: 19 (1921).
Phyllosticta lycopersici Pk. *Bull. N.Y. St. Mus.* 219-220: 55 (1887).

Colonies variable, usually with sparse aerial mycelium, but when present floccose and dark brown with patches of grey to whitish grey, often sectoring; reverse dark brown, often with a vinaceous tint. Conidia 3.5-5 x 2 µ, consistently biguttulate, as in the α-conidia of *Phomopsis* species, straight, cylindrical, ellipsoid or slightly irregular, reputedly produced in saffron tendrils.

For additional data see Boerema & Dorenbosch (1973).

This species and its relationship to *P. lycopersici* Cooke (anamorphosis of *Didymella lycopersici* Kleb.) have been the subject of discussion by Brookes & Searle (1921), Dennis (1946), Knight-Fisher (1960), Laundon (1971) and Boerema & Dorenbosch (1973). The consensus of opinion is that the two species can only be distinguished by cultural characters. *P. lycopersici* differs from *P. destructiva* by limited pycnidial production in colonies showing a well-developed aerial mycelium and stilboid aggregations of hyphae.

On and from *Lycopersicon esculentum*, U.S.S.R., India, Papua New Guinea, Guadeloupe, Nigeria, Sudan, Zambia, Mauritius, Libya (IMI 129003, 188639, 123242, 75370, 58540, 74643b, 22557, 184082, 173142, 124596, 138126, 206868, 202963, 229015, 62996).

P. EPICOCCINA Punithalingam, Tulloch & Leach, *Trans. Br. mycol. Soc.* 59: 341 (1972). (Fig. 227A)

Colonies extremely variable in pigmentation, showing a similar range to that found in *Epicoccum purpurascens*, aerial mycelium present or absent, zonate or not. Conidia 5-8.5 x 2.5-3 µ, eguttulate or with minute guttules, straight or slightly curved, cylindrical. *Epicoccum* state present, conidia 15-25 µ diam., verrucose, muriform.

From seed of *Dactylis glomerata*, *Avena* sp., and from *Beta vulgaris*, *Malus* sp., *Triticum* sp., *Zea mays*, U.K., Eire, India, N.Z., Ore., U.S.A. (IMI 164070, holotype, 183207, 165573b, 170490, 226928, 172767, 200403, 167908).

P. EUPYRENA Sacc., *Michelia* 1: 525 (1879). (Fig. 227B)

Colonies dark brown, quite variable, often with dense felty olivaceous green to brown aerial mycelium, rarely grey, at the margin mycelium usually submerged. Conidia 3-5 x 1.5-2 µ, cylindrical or ellipsoid, straight or slightly curved, often biguttulate. Chlamydospores pale, medium or dark brown, smooth, terminal or intercalary, often catenate, abundant.

Additional data from Dorenbosch (1970), Boerema (1976).

Represented in herb. IMI by about 100 collections from 30 different host genera, soil, sewage, sand and veterinary sources from Sri Lanka, Pakistan, India, Kuwait, Malaysia, Australia, New Caledonia, Norway, Eire, U.K., Canada, Nigeria, Malawi, Sierra Leone, South Africa.

P. EXIGUA Desm., *Ann. Sci. nat.*, ser. 3, 11: 282 (1849). (Fig. 227C)
Synonymy in Boerema & Höweler (1967), Boerema (1967a), Boerema (1976), Boerema & Dorenbosch (1973).

Colonies very variable with a scalloped or lobed margin, usually with dense felty white, black or dark olivaceous aerial mycelium, not concentrically zoned. Application of NaOH gives a blue-green pigmentation to the agar, changing to brown-red. Conidia 5.5-10 x 2.5-3.5 µ, straight or slightly curved, ellipsoid or cylindrical, often biguttulate and becoming 1 septate.

This species has been separated into five varieties by Boerema (1976) and the diagnostic features tabulated clearly.

P. exigua var. *exigua* is recognised by the above-listed features for the species.
P. exigua var. *linicola* (Naumov & Vass.) Maas (1965) causes foot rot and damping off of *Linum usitatissimum* and occurs on other plant substrates. It has a slower growth rate than var. *exigua*, produces more uniform colonies which are dominated by black tinges, and also shows the colour reaction by addition of NaOH.
P. exigua var. *sambuci-nigrae* (Sacc.) Boerema & Höweler (1967) is associated with leaf lesions and dead shoots of *Sambucus nigra*. It has a similar growth rate to var. *exigua* and shows a similar colour reaction to addition of NaOH, but is separated by the relatively uniform olivaceous mycelial mat and a colony margin that is entire and not scalloped.

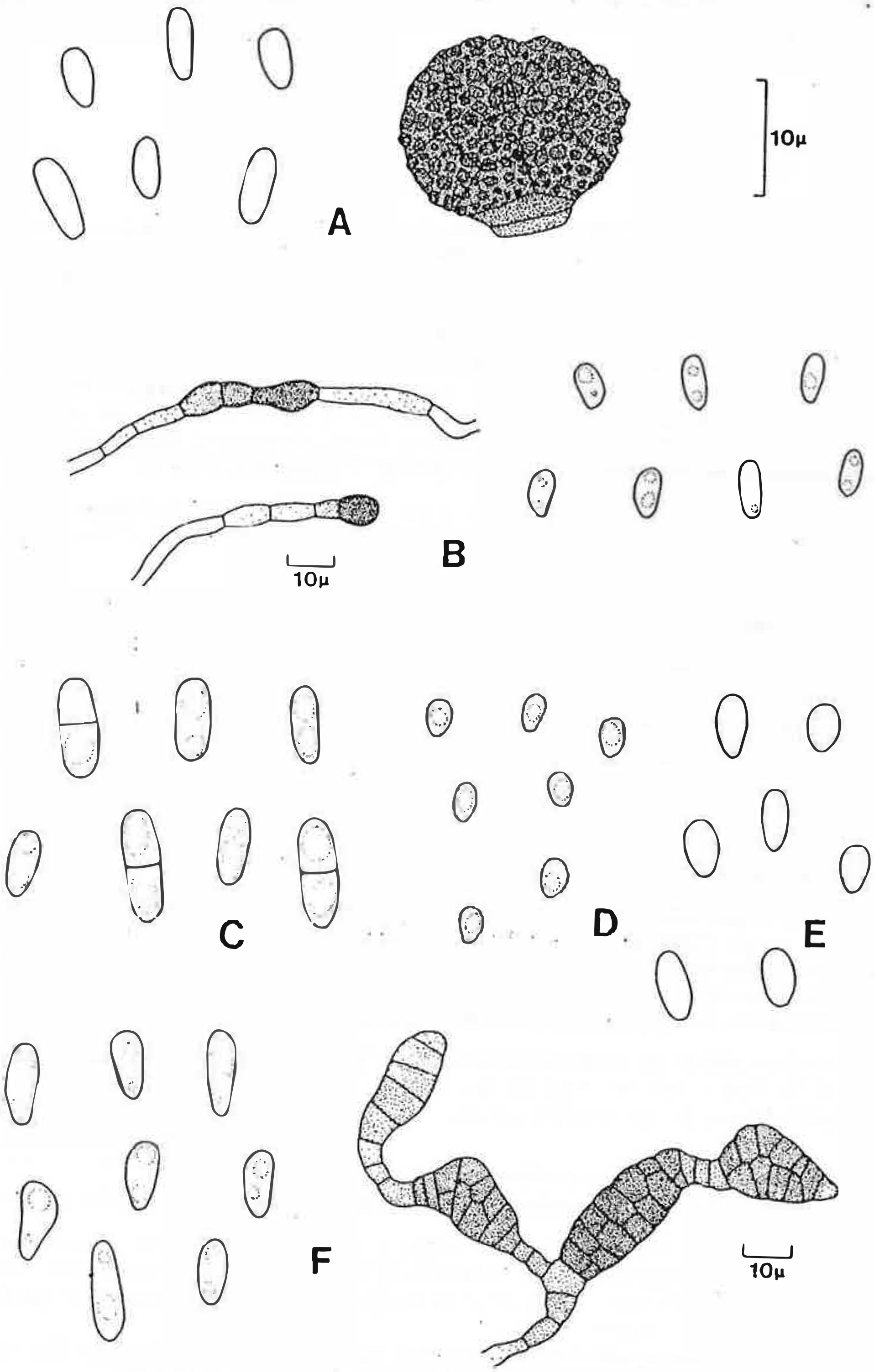

Fig. 227. A, *Phoma epicoccina*, conidia and *Epicoccum* conidium; B, *P. eupyrena*, chlamydospores and conidia; C, *P. exigua*, conidia; D, *P. fimeti*, conidia; E, *P. hedericola*, conidia, F, *P. glomerata*, conidia and chlamydospores.